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Changing Trend in Human Thoughts and Perspective: Science, humanities and Culture
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Part II

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A discourse on Balneotherapy – An ancient rejuvenating geomedical practice

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Abstract: Balneotherapy is a natural therapy which attempts the best use of natural elements such as hot spring water. In the historic past, people used geothermal water or miracle water for bathing and medicinal purposes. The word "spa" normally denotes a place where different medical treatments with thermal water are practiced. Different types of balneotherapic practices are bath cure, drinking cures, mud therapy, inhalation etc. Balneotherapy can be regarded as a kind of stimulus-adaptation therapy, because patients are repeatedly given therapeutic stimulation, including hot steam water bathing, exercises and other stimuli. The autonomic nervous system, endocrine system and immune system respond to these stimuli within a month in a non-specific manner. In the balneotherapic treatment, – heat, water, gas and mineral constituents – all are very important. Though balneotherapy is a very old traditional medical practice, it is still treated as an 'alternative medicine' in a country like India. However, rudimentary health tourism in the form of pilgrimage has already been developed surrounding the hot springs of India. Due to the multidisciplinary character of balneotherapy, there are ample opportunities to conduct research on the subject, especially in a country like India, and lots of innovative ideas may be developed and introduced in the field of geotourism and balneology.

Keywords: Balneotherapy, Balneology, medicinal water, thermal springs, geotourism, spa, health resort.

1. Introduction

Balneotherapy is a natural therapy which attempts the best use of natural elements such as hot spring water. The word "*balneo*" is derived from "*balneum*" in Latin, meaning "bath" in English. This therapy is carried out by hot-spring water bathing, various thermo and hydro therapies, physical exercise, drinking, inhalation etc. It is a very old traditional method to cure a disease. The rudiments of balneology appeared as early as the 5th century BC when Herodotus drew attention to the methods of prescription and application of mineral waters (Albu et al. 1997). In Japan, it is called "bath cure". Usually, the patients go to the *spa station* (health resort) in a cleaner environment and stay there for a period of time to enjoy the benefit of balneotherapic treatment.

2. Historical background of Balneotherapy

In the historic past, people used geothermal water or miracle water for bathing and medicinal purposes. Some of the ancient community considered the pungent hot spring water as panacea. Based on archaeological findings in Asia, mineral water has been used for bathing since the Bronze Age, about 5000 years ago (Lund 2005). Hot springs are regarded as sacred places in ancient Egypt. The Greeks and Romans were famous for developing spas and the

same traditional practice is found in the other parts of the world, such as in an island country like Japan. Health resorts were very common in the former Soviet Union and Czechoslovakia.

Therapeutic use of spa (thermal) waters has been a part of the cultural and medical traditions of the Europeans and especially the Central European (CE) nations. It is the culture of the middle and upper class people of that area to visit the health resorts regularly. The exclusive culture and balneological treatments were patronised by the former German Empire, Italy and Austro-Hungarian Monarchy (Varga 2010).

3. Spa and Health Resort: The Balneological Practicing Centre

The word “spa” normally denotes a place where different medical treatments with thermal waters are practiced. It is a place where there are hot-springs or related geological environment which are utilised for therapeutic purposes. An over-night accommodation facilities along with all modern amenities should be there in the spa.

The word “spa” is used as a Latin abbreviation for: S = salud, P = per, A = aqua, or “Health through Water”. In Germany, they refer to the “Kur”, which not only mean just a cure, but also refer to a series of treatments over time including baths, taking (drinking) water, massage, exercise, mud baths, etc. (Lund 2005). The term “cure treatment” is derived from the German word “Kurbehandlung” which means taking medical balneotherapy during a long term stay in a spa (Agishi & Ohtsuka 1998). In the modern world, the spas provide: (a) hydrothermal treatment, (b) Body shaping such as exercise, massage and fitness training, (c) herbal medical benefits and (d) life-style amenities. It is therefore spread over a multi-faceted field, and it deviates far from its original service.

4. Architecture and Design of a Spa

History of balneology and the importance of medical resorts have a long history starting from the Roman civilization, even from the pre-Roman time. The ruins of the Roman spa are found in Macedonia and several other places. Arabic medicine shared the medical knowledge with Greeks and Romans and ‘*hammam*’ or public-health bath house took a vital role in the daily life of elites of ancient Arab (Sherwani et al. 2006). There developed some special professions in association with hammam such as ‘*bathman*’. Bathmen are the doctors or skilful health personnel who had been trained for the arrangement of the degree of heat required to maintain the temperature of bath house. All types of bath were available in Hammams namely cold, very hot or sub-tepid bath, mineral bath and/or spring bath (*hammam hammat*). The record indicates that hammam provided the promised cure to innumerable diseases, especially of chronic origin like hypertension, obesity etc. Paralysis

was alleviated completely when such bath was practiced with different herbal oil massages, and cupping therapy[1] as stated by different Unani physicians.

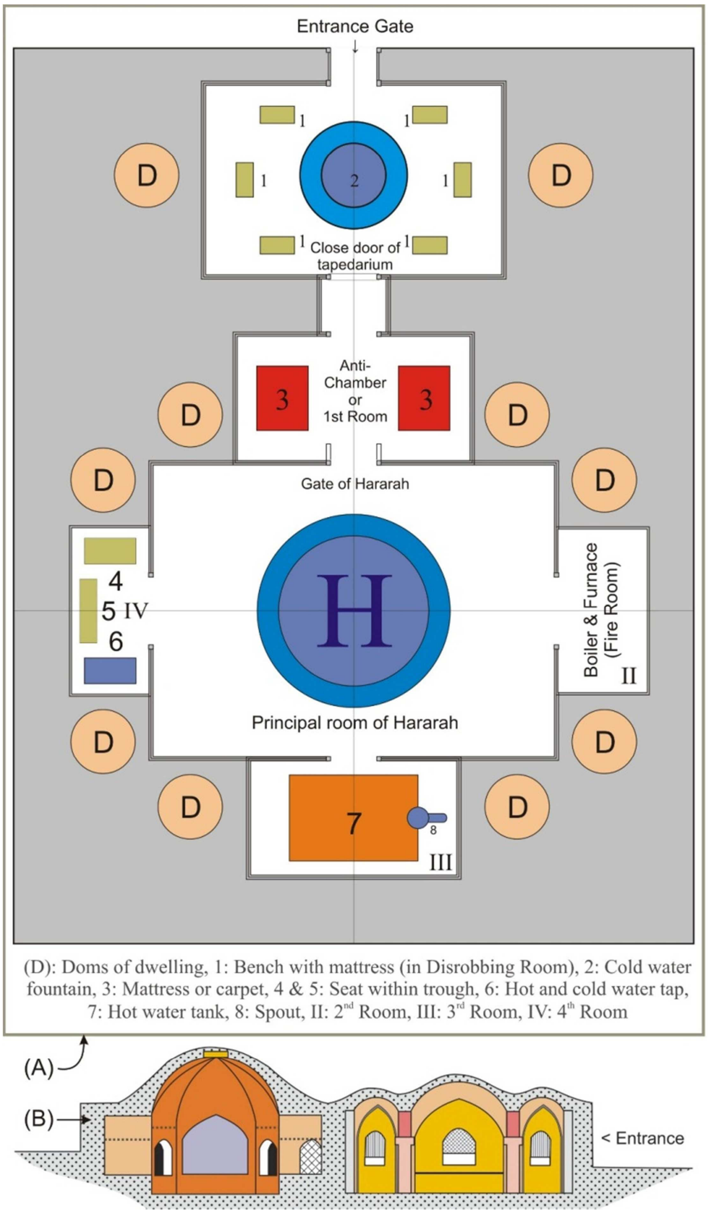

Figure 1: Sketch diagram showing ancient hammam (Public health bath house of Arab): (A) Plan view, (B) Section

The structure of the hammam is scientific and well organised. The important components are (Sherwani et al. 2006):

1. First apartment (disrobing room).
2. Principal bath house or square-shaped inner division of the building.
3. Chamber of the fire and boiler house for supplying hot water.
4. Third chamber: It contains a warm water tank fed by a spout into the dome (calidarium).

[1] **Cupping therapy** is an ancient form of alternative medicine in which a therapist puts special cups on your skin for a few minutes to create suction.

5. Fourth chamber: It was having two taps side by side, one hot, one cold and seats before the taps (frigidarium)
6. Harárah or chief portion or central part of principal bath house: It holds the shape of a cross containing all above-described chambers on its respective four angles (Figure 1).

The spas and medical resorts, therefore, have a legacy supported by historical, archaeological and architectural evidence. A comparative study between the ancient spas (hammams) and modern resorts can provide a complete idea about bath houses. Plan and structure of a modern spa depend on local culture - the balneological practices that have been adopted and practiced in that spa and available geothermal setting. Each and every spa is different from the other. However, on the basis of the use of geothermal water, there are two common plans for the hot water spas (Woodruff & Takahashi 1990). The unique design presented here was originally designed for a volcanic island of Hawaii, where geothermal water, local materials are used to develop the spa and native plants are used for landscaping and gardening (Figure 2). The second design (Figure 3) was adopted from the typical design for the Polynesian Pools in Rotorua, New Zealand. In this resort semi-private and private pools can be used by a single family or a small group on the basis of hourly rent. Though food-court and restaurant are available in the design, no lodging facilities are there within the arena. In both the cases, the pools may be covered, uncovered or there may be a provision of occasional covering for unpleasant weather. Figure 4 gives an idea of lifestyle, luxury and facilities of modern spas.

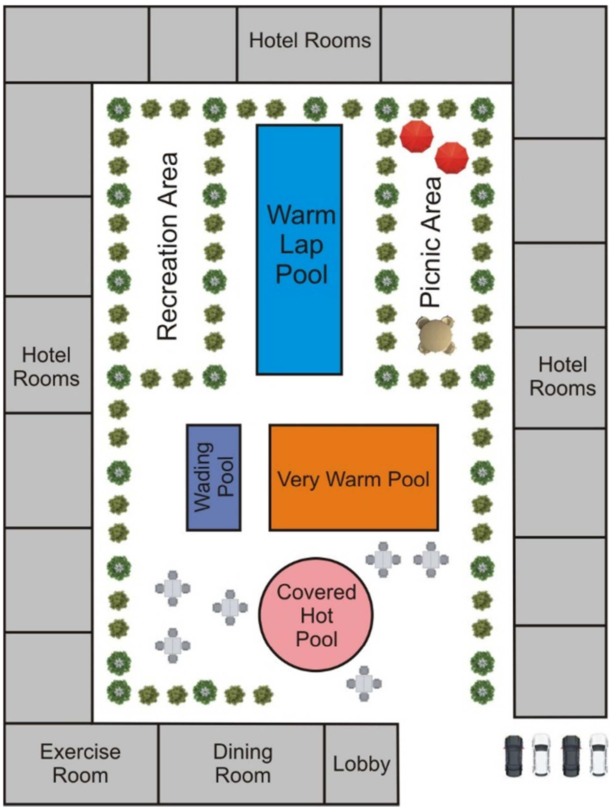

Figure 2: General scheme of a modern geothermal spa located in California

(Modified after Woodruff and Takahashi, 1990).

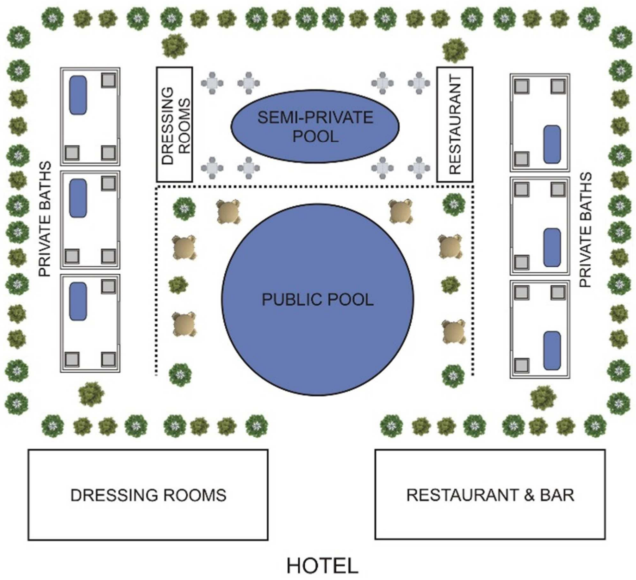

Figure 3: Design for a geothermal spa offering private, semi-private, and public bathing facilities (Modified after Woodruff and Takahashi, 1990).

5. Importance of Balneotherapy in Modern Lifestyle

The modern lifestyle is full of stress and anxiety. The modern lifestyle related health problems like high or low blood pressure, blood-sugar etc. are very common now-a-days. In a health resort, a combination of balneotherapy along with other conventional medicines is practiced to reduce the health problem and the treatment is becoming popular day by day for its magical response without any adverse side effects. In the recent time, various other good practices like mental and physical health education, psychological counselling, sports therapy, dietary counselling, relaxation therapy etc. are adopted in the course of treatment, especially in the practice of health resort medicine. Though they are not associated with the traditional balneological practices, they have a specific positive impact in the treatment process. However, they are not elaborated here and are beyond the scope of our discussion.

Different types of balneotherapic practices are bath cure, drinking cures, mud therapy, inhalation etc. Fangotherapy is a treatment of the human body in which mineral-rich thermal mud, clay or peat is spread over the body for purification, revitalisation, and to reduce toxins. Thalassotherapy is the therapeutic use of seawater in cosmetic and health treatment. Though it is practiced in some health resorts, thalassotherapy, in the strictest sense, is not related to the balneological practices.

The most fundamental aspect of balneotherapy is the bath cure, that is hot spring water bathing. It is a habit of taking very hot water baths up to neck level at a temperature of 42°-44°C for a relatively short time duration such as 5-10 minutes. In case of high temperature geothermal water, it is left in open tanks to cool down to the desired temperature or is mixed

with inexpensive cold tap water. In the second case, mineral composition of original water changes reducing its efficiency as a natural medicine. The usual posture of bathing is a long-sitting or squatting position (Agishi & Ohtsuka 1998).


(A)


(B)

Figure 4: Modern spas and health resorts. (A) The Széchenyi Baths (built in 1913) consist of three huge outdoor pools that are open all-year round, providing a great spot to cool off on hot days. (Photo source: CNN) (B) Eskisehir Spa and Thermal Hotel in Turkey (Photo source: architonic.com)

Bathing in water itself is a good exercise. Generally, exercises are of two types – active (yoga, athletics, gymnastics etc.) and passive (body massage). In bathing and swimming, physical exertion is an active participation, whereas the wave action in return provides an effect of passive massage. Therefore, the direct benefit of taking a hot-water bath is the physical effects such as buoyancy, hydrostatic pressure, viscosity of geothermal water etc. The other advantages are thermal, pharmacological and hydro-chemical effects. The temperature of the water-bath should be within the range of human tolerance, usually at a maximum level of 42°C. Some of the endocrine glands are reactivated and secrete more hormones at increased temperatures. Glutathione, an antioxidant naturally found in human cells, is capable of preventing damage to important cellular components caused by reactive oxygen species such as free radicals, peroxides, lipid peroxides, and heavy metals. It neutralises free radicals, boosts the immune system and detoxifies the body. It is observed that hyperthermia treatment with heat stress may cause oxidative stress, and cold stress is thought to augment the activity of the antioxidant defence system (Agishi & Ohtsuka 1998). Subsequent bathing in more than one time in a day for consecutive days stimulates the immune system of the body by glutathione metabolism in human erythrocytes and platelets by water bathing.

Balneotherapy can be regarded as a kind of stimulus-adaptation therapy, because patients are repeatedly given therapeutic stimulation, including hot steam water bathing, exercises, and other stimuli. The autonomic nervous system, endocrine system and immune system respond to these stimuli within a month in a non-specific manner. The potential level of physiological functions, in turn, are normalised which enhances the resistance potentials to endogenous and exogenous abnormal stimuli (Agishi & Ohtsuka 1998).

Recently people are habituated to live either in an artificial environment like air-conditioned office or apartment with artificial illumination or in an environment highly polluted with air, water, odour and/or sound pollution. Duties in night-shift and socio-economic strain due to ups and downs in money market are very common in the modern world. All these create lifestyle diseases along with some diseases related to stress-full life. On the other hand, medical support system enhances the normal span of life, which increases the ratio of old and aged persons in a society. Under this condition, the chronic disorder of health, the deterioration of hygiene and the frequency of functional diseases increase progressively. Thus it should be emphasised that balneotherapy is especially appropriate not only for the prevention and therapy of these disorders, but also for health promotion (Agishi & Ohtsuka 1998). The common physical disorders and diseases which confirm a good response to balneotherapic treatment are (Agishi 1995):

1. Prevention of adult diseases and occupational diseases
2. Building up physical strength, promoting health etc.
3. Chronic diseases
   A. Chronic rheumatic diseases
   B. Functional recovery of central and peripheral nervous neuro-paralysis
   C. Metabolic diseases such as diabetes, obesity and gout
   D. Chronic gastrointestinal diseases
   E. Chronic mild respiratory diseases: Young patients of bronchial asthma
   F. Circulatory diseases (moderate or less severe hypertension)
   G. Peripheral circulatory disorders
   H. Chronic dermal diseases such as eczema, dermatitis, psoriasis etc.
   I. Psychosomatic diseases and stress-induced diseases.
   J. Autonomic nervous dysfunction
   K. Vibration disorder
   L. Sequel of trauma
   M. Chronic gynaecologic diseases
4. Rehabilitation treatment after orthopaedic surgery.

In today's stressful and aging society, balneotherapy should be used effectively not only for the treatment of chronic diseases and rehabilitation, but also for preventing life-habit-related diseases which cannot be cured by drug therapy, and for maintaining and promoting health as well as establishing wellness in which the body and the mind are in good balance (Agishi & Ohtsuka 1998).

6. Hydrogeochemistry of geothermal waters

Japan has a long tradition and culture of balneotherapy. According to the definition of Japanese hot spring law the temperature of the water at source must be 25°C or more and that natural water must contain some radicals more than that the normal average (Agishi & Ohtsuka 1998). The important ingredients are free carbonic acid (H_2CO_3), and radicals of Lihium (Li), Strontium (Sr), Barium (Ba), ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions, manganous

(Mn^{2+}) ions and ions of Hydrogen (H^+), Bromine (Br^-), Iodine (I^-), Fluorine (F^-), hydro-arsenic acid ($HAsO_4^{2-}$) and different compounds like meta-arsenic acid ($HAsO_2$), sulphur (HS^-, S_2O_3, H_2S etc.), meta-boracic acid (HBO_2), meta-silicic acid (H_2SiO_3), sodium bicarbonate ($NaHCO_3$) and some exceptional elements like Radon (Rn) or Radium salts (Ra).

There is a direct relation between total dissolved solids (TDS) and temperature of the water. The low temperature geothermal water usually contains dissolved solids in the range of 200-400 mg/L, whereas the high temperature fluids contain more than 1000 g/L (Kristmannsdóttir & Björnsson 2003). In Japan 2-3 g/L solids are very common in high-temperature volcanic water. The geothermal waters are usually meteoric in origin. Percolated water from the near-surface aquifer usually goes down to the deep interior of the crust, where it comes in contact with intruded magma and released out as geothermal spring. So, the recharge area of thermal aquifer should be in close vicinity to the subsurface heat source, such as magmatic intrusion within the crust. Hot-water springs of Leh and Ladakh are hydrothermal in origin. These are directly related to some subsurface igneous activity related to the Himalayan mountain building process. However, magmatic source of heat has no significance in the hot spring of peninsular India as there is no known recent igneous activity in the Indian shield. Regional high heat flows in the shield may be one of the reasons for the development of hot-spring. The presence of radioactive and inert gases such as Radon and Helium indicates a radiogenic heat source. Sometimes the reaction of seepage water with limestone or sulphide ore produces pungent low-temperature water. The gas content of the hot-spring may guide us to know the type of reaction and its use as a medicinal agent. Sometimes heat generated from the exothermic reactions during metamorphism might be accumulated in the geological past and come to the surface as a hot-spring. In a few cases, the heat source may be the frictional heat generated along the fault plane due to tectonic movement. In that case, the hot groundwater includes less mineral matter and is medically less appropriate for balneological use.

In the balneotherapic treatment, – heat, water, gas and mineral constituents – all are very important. The pH of the water is one of the indicators that can be used to get the immediate information of the medicinal water. Most of the waters considered for treatment of hydrotherapy or balneotherapy is not neutral in nature ($pH \neq 7$). They may be acidic in the presence of carbonic acid and sulphur and the pH may be as high as 1.4, which is used in "Jikan-Yu" therapy for dermal diseases in Japan (Agishi & Ohtsuka 1998). pH values are lower in high temperature water and it may increase as high as 11 (usual range pH = 9-10) in comparatively low temperature geothermal water. Similarly, the silica concentration of the waters is in direct relation with increasing temperature, carbonate concentration is in inverse relation to increasing temperature and the waters are highly depleted in magnesium, even at moderate temperatures (Kristmannsdóttir & Björnsson 2003).

The gases, which are very common in geothermal or balneological fluid, are carbon dioxide (CO_2), hydrogen sulphide (H_2S), methane (CH_4), hydrogen (H_2) and nitrogen (N_2). A comparable level of N_2 in some geothermal gases suggests that N_2 has been derived from the atmosphere along with meteoric water (Saxena1987). Dissolved oxygen level is always less

than the atmospheric concentration and helium (He) and argon (Ar) are common constituents in some springs, indicating their radioactive heat source. High CO_2 content is generally associated with the geothermal system in volcanic and magmatic areas (Arnorson & Barnes 1983). However, CO_2 of meteoric origin is also very common and derived through metamorphic and/or organic process. Presence of methane may be endorsed by the decomposition of organic matter inside the earth's crust. Hydrogen sulphide may be produced by heating of rocks containing sulphide minerals and organic matter, which imparts sulphur smell to the surrounding (Mahala 2019).

7. Geothermometry of Aquifer and Types of Thermal Manifestations

A very common classification scheme of geothermal water is based on the temperature as well as their impact on their potential use. Using this scheme, geothermal springs are ranked as low enthalpy (<100°C), moderate enthalpy (100°C to 175°C), and high enthalpy (>175°C) (Boden 2017, Ghosh 2020). Most of the geothermal waters of the Indian subcontinent are low-enthalpy type.

Any water-bearing geological formations are called aquifer (aqua-bearing formation). Geothermal systems or high-temperature aquifers are found in different parts of the world in the geological settings. These are basically the source of hot spring water. Nicholson (1993) offered a geothermal classification system based on the reservoir equilibrium, fluid type and temperature as follows:

1. Convective geothermal systems (dynamic systems): The system where meteoric water enters into the deep interior of the crust through cracks, comes in contact with heat source (usually near-surface magma) and returns to the surface as hot-spring.
   a. High temperature: liquid- and vapour-dominated
   b. Low temperature
2. Conductive geothermal systems (static systems): The system where heat comes to the surface through conduction.
   a. Low temperature
   b. Geo-pressurised (a special setting like an oil-bearing reservoir)

It was thought that the classification of the geothermal as well as hydrothermal systems had no significance in the practice of balneotherapy. In recent time, an emphasis has been given on understanding the origin of the thermal spring before going into randomised trial in medical sector.

8. Balneological Classification of Waters

It is hard to classify hot spring waters in terms of their therapeutic properties. The main problems are:

(a) Each and every thermal spring is unique and the chemical composition of expelled water differs from one spring to another. Therefore, it is hard to classify these waters on some fixed chemical and medical parameters.
(b) Though the quality of drinking water has a specific norm based on the directive of the World Health Organisation (WHO), only a few countries have specific regulations or acts on thermal water.
(c) Central European countries like Hungary, Slovakia, and Romania developed some regulations on 'mineral water' based on simple analogical studies (Varga 2010). However, whether these waters meet the criteria of a 'medical water' or not, that is yet to be identified.
(d) Biological activities and organic components of geothermal waters are not well-studied and the absorption of different chemical components of that water in human body through skin is yet to be studied scientifically. Lack of knowledge is also responsible for not developing a true classification scheme.
(e) The healing effects of balneotherapy in wide range of diseases are well described (Nasermoaddeli & Kagamimori 2005), however, exact mechanism of the healing spa cure and its relationship to the presence of certain chemical ingredients are completely undefined. So, the classification of medical water, based on their chemical ingredients, is not possible.

Table 1: Classification of medicinal waters as per Papp's system (Papp 1957).

Category	**Main features**
Simple thermal waters	≥ 25°C
Simple acidic (carbonised) waters	≥ 1 g/L free CO_2
Alkaline (Na-K-bicarbonated) waters	≥ 1 g/L total dissolved solid, Dominant anion: $HCO3^-$
Ca-Mg-bicarbonated waters	≥ 1 g/L total dissolved solid, Dominant cations: Ca^{2+}, Mg^{2+} Dominant anion: HCO3-
Chloridated (saline) waters	≥ 1 g/L total dissolved solid, Dominant cation: Na^+ Dominant anion: Cl^-
Ironic (ferrous) waters	≥ 10 mg/L Fe^{2+} or Fe^{3+}
Sulphuric waters	Total sulphur ≥ 1mg/L (HS or $S_2O_3^{2-}$ or S^{2-} or H_2S)
Sulphated waters	≥ 1 g/L total dissolved solid, Dominant anion: SO_4^{2-}
Iodated-brominates waters	≥ 1 mg/L I or ≥ 5 mg/L Br^-
Radioactive waters	Radon or toron (^{212}Pb) content

Following traditional methods and existing knowledge-base, Papp (1957) classified medicinal geothermal water into few groups based on their chemistry (Table 1). The classification scheme was very simple and it did not satisfy the purpose of a medical practitioner. Though spa waters used in prevention and therapy, balneotherapy and balneoprevention have some

indigenous problem: if the spring water 'A' contains chemical 'B' and the water 'A' successfully cures the disease 'C'; that does not mean that the chemical 'B' is responsible for curing the disease 'C'. Therefore, the exact inorganic analytical study cannot predict the therapeutic efficiency and more *medical trial* is necessary for qualifying a spa water to be a '*Medicinal Water*' (Varga 2010). Presence of some chemical constituents in terms of ppm or ppb level might influence the healing and curing property of so called medicinal water. There is enough scope of research in this field of medicinal chemistry.

However, attempts were made to classify thermal water based on their single property and the obvious choice was the temperature as the major criterion for classification. On the basis of temperature, water can be classified as (a) Cold (< 25°C), (b) tepid (25-34°C), (c) warm (34-42°C) and (d) hot (> 42°C) (Karagülle & Karagülle 2014). A similar classification scheme was proposed by Vouk (1923): (a) Hypothermal (cold) (<18°C, (b) Chliarothermal (tepid, 18-30°C), (c) Euthermal (warm, 30-50°C), (d) Acrothermal (hot) (50-70°C), and (d) Hyperthermal (steaming, 70°C or higher). The Vouk fixed the temperature in an arbitrary manner; however, the recent scheme considers the thermal tolerance of human body. The normal human body temperature is 37°C or 98.6°F. The temperature 37±1°C shows an isothermal effect and it is clear from the general principle of heat transfer that at a higher temperature heat is transferred from water to the body and at temperatures below 35°C it has a cooling effect. So, this average body temperature may be considered as an index in the hydrotherapy treatment. On the basis of diurnal and seasonal variation, the thermal spring may be homothermal or heterothermal. On the basis of morphological criteria (Schwabe 1936, Tuxen 1944) hot springs are divided into: (a) Limnotherm – a hot spring having a basin at the head, where surfacing waters collect prior to spilling over; and (b) Rheotherm – a hot spring where there is no storage basin at the head. Yoneda (1952) classified the various hot springs of Japan on the basis of algal flora in 5 types; viz. (a) *Synechococcus* type, (b) *Cyanidium* type, (c) *Mastigocladus* type, (d) *Oscillatoria* type and (e) *Phormidium* type. These classifications do not satisfy all the qualities of medicinal water for therapeutic use. Several successive classification schemes have been proposed (Vintras 1883, Kisch 1906, Peale 1906, Acciaiuoli 1952, Gomes et al. 2019 etc.) for the need of classifying different types of geothermal waters from different geological settings, but no one of them is all-inclusive type.

The scientific approach towards the classification of medicinal water was traced back to last half of 18^{th} century when it was classified under the groups: (1) cold acidulous; (2) thermal acidulous; (3) sulphuric saline; (4) muriatic saline; (5) simple sulphurous; (6) sulphuretted gaseous; (7) simple ferruginous; (8) ferruginous and acidulous and (9) sulphuric ferruginous (Gairdner, 1832). Different independent classification schemes were developed in accordance with the need of the local community in different countries like America, France and Germany. Following the major ionic constituents medicinal waters are classified in a simple scheme (Albertini & Dachà 2007) as:

- Oligo-mineral and low mineralised water
- Sulphurous water
- Salt-bromine-iodine water

- Radioactive water
- Salt water
- Sulphate water
- Bicarbonate and carbonic waters
- Ferrous, arsenic water.

Komatina, (2004) indicates the division of medicinal waters as four (4) basic groups on the basis of concentration of mineralisation and eight (8) balneological applicable groups with respect to the presence of important components. The important parameters are:

A. Mineralisation and suitability for treatment by drinking or bathing

Type	Mineralisation (g/L)	Use
Waters with elevated mineralisation	1 to 5 g/L	Consumed for drinking
Waters with medium mineralisation	5 to 15 g/L; osmotic concentration approaches that of blood plasma	Suitable for balneology; taken as medicine
Waters with high mineralisation	15 to 35 g/L	Used exclusively for bathing purpose
	Brines 35 to 150 g/L	Used exclusively for bathing purpose

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B. Classification based on the presence of specific components

	Type	Mineralisation	Other features	Use
1.	Medicinal mineral water without specific components and properties	150 g/L	Nitrogen and methane gas	
2.	Carbonated mineral water	Fraction of g/L to 90 g/L	High concentration of carbon dioxide Variable chemical composition HCO_3 dominant anion	Treat disease of stomach, intestine, bile and urinary duct
3.	Hydrogen sulphide waters	More than 500 g/L	Diverse chemical composition, mineralisation and H_2S concentration. Include sulphates and chlorides	Bathing in water treat disease of skin, rheumatism and nervous disorders
4.	Radioactive mineral water	Ra >1.0^{-11} g/L U > 3.0^{-5} g/L Rn > 1.85^2 Bq/L	Balneology use radon	Nervous, cardiovascular diseases; skin ailments and gynaecological diseases
5.	Iron water, arsenic water and water with elevated content Mn, Al, Cu and Zn	Fe lower limit 20 mg/L As lower limit 0.7 mg/L		
6.	Bromine and iodine waters	Br > 25mg/L or I > 5mg/L		Drink and bath
7.	Waters with high content of organic substance	Variable: Several mg/L to more than 400 mg/L	Peat bog, mud flats, petroleum deposits	

8.	Silicic water	Si > 50 mg/L as H_2SiO_3	Present in thermal and high thermal water, Temperature > 35 °C Waters often contain medicinal Rn and CO_2 and other trace elements

The indicated classification makes it possible to ascertain from mineralisation values their suitability for treatment by drinking or bathing (Komatina 2004).

Considering data from German, Japanese and Icelandic geothermal water resources a generalised balneological classification of waters can be proposed (Kristmannsdóttir & Björnsson 2003). The balneological waters can be grouped as:

1. Carbonate water containing total carbonate (calculated as CO_2) in excess of 300 mg/L
2. Sulphide water containing H_2S in excess of 1 mg/L and of temperature > 40°C.
3. Highly mineralised warm (>40°C) waters with TDS (total dissolved solids) exceeding 1000 mg/L.
4. Iron rich water containing iron in excess of 20 mg/L and of temperature >40°C.
5. Fluoride water containing fluoride in excess of 2 mg/L and of temperature >40°C.
6. Iodide water containing iodide in excess of 1 mg/L.
7. Radioactive water containing radon in excess of 666 Bq/L.

This scheme was proposed for Icelandic health resort water and unfit for the classification of Indian hot-spring water. The hot springs of the Himalayan region have a magmatic association, whereas the peninsular hot-springs are completely non-volcanogenic. For example, the chemical analyses indicate that the spring waters of Odisha are Oligo-mineralic, but not identical to one another in their chemical characters. They are categorised mainly under three types, i.e. (i) sodium chloride (NaCl) type, (ii) sodium bicarbonate ($NaHCO_3$) type and (iii) calcium bicarbonate ($CaHCO_3$) type (Mahala 2019).

In recent times, the balneological classification of geothermal water is based on the mineralisation of waters. Three groups are: simple (TDS < 600 mg/L), oligo-metallique (700 – 1000 mg/L) and highly mineralised (>1000 mg/L).

As per the directive of the European Union, the important ingredients (in terms of TDS) of medicinal thermal waters are given in Table 2. The specifications prescribed by WHO and Indian Standards indicate that most of the thermal spring waters of peninsular India are suitable for drinking and domestic uses as most of the parameters are within the permissible limits with few exceptions (Mahala 2019).

In the recent past, it is becoming popular to classify medicinal water in the Piper diagram, which was initially developed by the Piper for illustrating the geochemistry of geothermal water. In Piper triangular diagram (Piper 1944), the relative concentration of cations (Na, K, Ca, Mg) and anions (Cl, CO_3, HCO_3, SO_4) are plotted to understand the chemical nature of water (Figure 5). This diagram is a combination of four triangular diagrams, out of which the

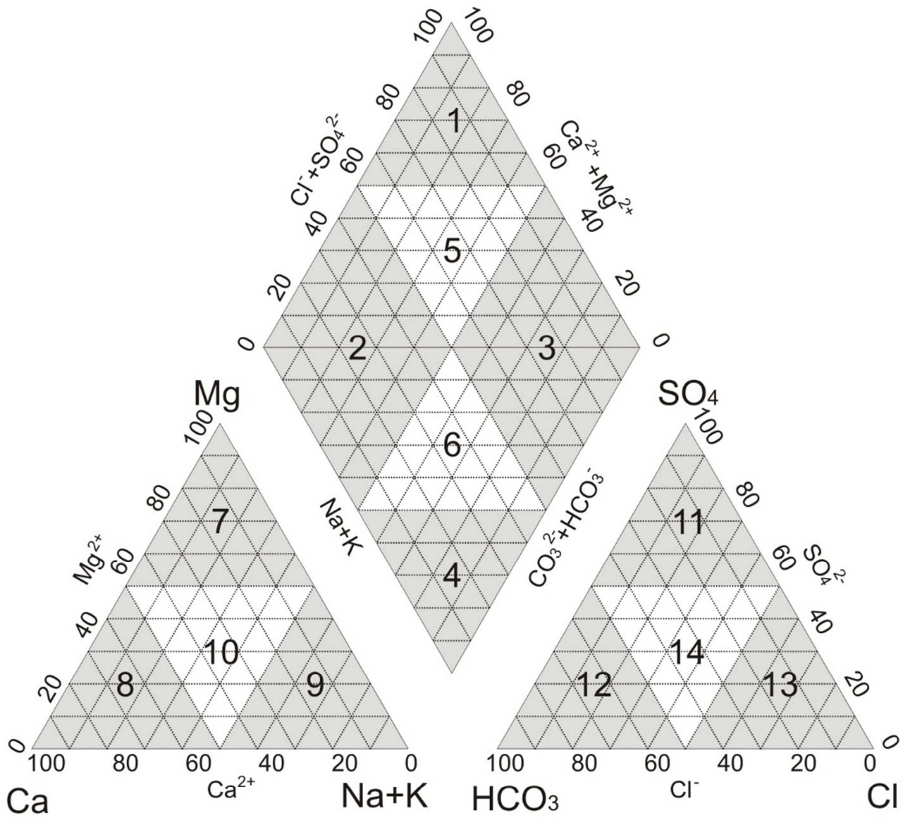
middle one is inverted. Actually, there are two triangular diagrams in the two sides of the base of the triangle, and one normal and one inverted triangular diagrams joining at the base form a diamond or rhomb, which forms the apex of the piper diagram. Piper diagram is now used to differentiate two similar medicinal waters collected from different sources and to identify their potential to be used for treating illness. However, the problem of using the Piper diagram to present the major ions in balneological classification is that the concentrations are renormalised. Also, Piper cannot accommodate all types of ions of water, which may be significant.

Table 2: Criteria for mineral waters in accordance with the EU mineral water directive (After Van der Aa 2003)

Mineral water type	Criterion
Very low mineral concentration	Mineral content (TDS)<50 mg/L
Low mineral concentration	TDS 50–500 mg/L
Intermediate mineral concentration	TDS 500–1500 mg/L
High mineral concentration	TDS >1500 mg/L
Containing bicarbonate	Bicarbonate >600 mg/L
Containing sulphate	Sulphate >200 mg/L
Containing chloride	Chloride >200 mg/L
Containing calcium	Calcium >150 mg/L
Containing magnesium	Magnesium >50 mg/L
Containing fluoride	Fluoride >1 mg/L
Containing iron	Bivalent iron >1 mg/L
Acid	Carbon dioxide >250 mg/L
Containing sodium	Sodium >200 mg/L
Suitable for low sodium diets	Sodium <20 mg/L

Table 3: Terms related to the use of thermal and mineral water associated with medical treatment.

Term	Definition
Taking the waters	Bathing in water for therapeutic purposes
Balneotherapy	Treatment employing bathing in thermal or minerals waters, gases or peloids, drinking water or inhaling gases or water
Balneology	The scientific field dealing with balneotherapy
Thalassotherapy	Treatment employing bathing in sea water or sea products
Hydrotherapy	Treatment immersing a part of or the whole body in plain water, often employing exercises, or the application of water jets
Pelotherapy	Application of peloids (mud or clay) for therapeutic purposes
Fangotherapy	Application of mud, peat, and clay for healing. purposes (*fango* is the Italian word for mud).
Cryotherapy	Application of low temperatures to decrease inflammation, decrease pain and spasm, promote vasoconstriction. (In some countries people use the term cryotherapy instead of balneotherapy).
Climatotherapy	Application of climatic factors for the prevention or treatment of disease or for rehabilitation



1: Calcium chloride type; 2: Magnesium bicarbonate type; 3: Sodium chloride type;
4:Sodium bicarbonate type; 5 & 6: Mixed type; 7: Magnesium type, 8: Calcium type;
9: Sodium & potassium type; 10: No dominant type (Mixed type); 11: Sulphate type;
12: Bicarbonate type; 13: Chloride type; 14: No dominant type (Mixed type).
(2+5+1): Alkaline earths exceed alkalies; (4+6+3): Alkalies exceed alkaline earths;
(2+6+4): Weak acids exceed strong acids; (1+5+3): Strong acids exceed weak acids.

Figure 5: Piper trilinear diagram

9. Therapeutic use of Geothermal Water: The balneological approach

Though balneotherapy is a very old traditional medical practice, it is still treated as an *alternative medicine* in a country like India. The use of different terms of balneotherapy is quite uncommon to general people. Different connotations are available for a single term and at the same time, same group of jargons are used to denote the similar but slightly different situations. For example, Latin speaking countries often use the term '*Crenotherapy*' instead of balneotherapy (Varga 2010). Therefore, a comprehensive terminology is required to explain the usefulness of thermal groundwater. It is described in Table 3.

The simple thermal water includes oligo-mineralic water or hot water with a negligible amount of mineral, and the water is characterised by heat and temperature. However, the curative action of the chemical components in waters may be related to the presence of individual ions (Nghargbu et al., 2013).

The medicinal properties and impact of different ions present in the geothermal water are given below:

9.1 Bicarbonate

The ions are especially important to treat rheumatism, skin disease and digestive disorders.

9.2 Sulphate

Sulphate water, represented by a higher concentration of SO_4, is antitoxic and antiseptic, has respiratory and anti-dermatitis effects, and is essential in the fluids of joints. Sulphate water is also used as a purgative and laxative, when internally taken as drinking water, which is beneficial for liver and gastrointestinal conditions (Dulaymie et al. 2013). Important applications are in the treatments of eczema, skin diseases, gastritis, respiratory problem, gout and rheumatism.

9.3 Chloride

Chloride water is essential for metabolic stimulation, and mineral springs naturally rich in chloride are beneficial for rheumatic conditions, arthritis, central nervous system, posttraumatic and postoperative disorders, as well as orthopedic processes and gynecological diseases (Mitija 1999).

9.4 Fluorine/Fluoride

Fluorine is essential for fibres of the skin, vertebrates, bones, and teeth. It provides hardness and stability, especially on the surface area. The efficiency in F concentrations leads to dental caries (Edmunds and Smedley1996). F^- concentrations more than 2.4ppm may cause skeletal fluorosis; in that case, the fluoride is classified as a toxic agent.

9.5 Bromine/Bromide

Br^- accompanied with other tracers like zinc and rubidium has a good ability to penetrate into psoriatic skin and effective for healing skin infection (Dulaymie et al., 2013).

9.6 Iodine

Iodine water acts on cardiac and circulation system, thyroid function, lipid metabolism, and respiratory diseases. It has an antioxidant defence mechanisms and a positive impact on the treatment of arteriosclerosis, diabetes mellitus and cataract (Winkler and Klieber 1998).

9.7 Iron

A higher concentration of iron in water for bathing and drinking is beneficial for anaemia and diseases like alopecia. Iron-rich water is sometimes referred to as chalybeate, ferruginous or ferrous water. Iron concentrations in bathing and drinking water benefit anaemia healing and alopecia diseases; iron is considered as a stringent agent as well as responsible for oxygen transport from the lungs to the other parts of the body. It cures the problems of infertility, anaemia, hangover, obesity and genital disability.

9.8 Magnesium

It is very important component to treat eczema, skin diseases, respiratory, gastritis, heart-burn and tubercular diseases and diseases of bladder and kidney.

9.9 Silica

Silica and Silicic acid (H_2SiO_3) provide healing effects to various body organs and immune systems. Silica water has been successfully used for treating atopic dermatitis, allergic rhinitis and conjunctivitis (Ghersetich et al. 2001).

9.10 Zinc

Tracers of zinc concentrations are needed in tissues to restore protein syntheses (Mitija 1999).

Table 4: Chemical classification of geothermal mineral waters base on their balneological effect

Chemical type of mineral water	Principal physiological properties	Principal medical use
Bi-carbonated water	Stimulating action on the hepatic and intestinal function, on certain general metabolism (excretion of uric acid, hypo-glycemiating effect)	Gastro-intestinal illness; hepatic insufficiency; gout
Sulphated water	Stimulating action on the billary and intestinal function; diuretic action gastro-intestinal illness	Hepatic insufficiency; problems with accumulation of organic waste
Sodium chlorinated water	Stimulating action on growth and cicatrisation (osseous tissue in particular)	Podiatry; after effects of osteoarticular traumatisms; chronic infection of the mucous membranes
Sulphurated water	Trophic effect on the skin and mucous membranes; antalgic, antispasmodic action	Chronic infections of the mucous membranes; rheumatology; spasms (digestive in particular); metabolic illness Treatment of skin diseases
Radioactive mineral waters	Uranium, Radium and Radon bearing water Effects on rheumatism and arthritis, heart and cancer.	Treatment of on rheumatism. arthritis and cancer.

9.11 Other trace elements

- Arsenic is fatal to the human body, but helpful in balneology. It has therapeutic use in chronic rheumatism, tuberculosis and respiratory diseases.
- Cu concentrations are essential for collagen-elastic syntheses, while Mo is essential for amino acid metabolism synthesis.
- Apart from these, the presence of aluminium, boron, chromium, cobalt, lithium, manganese, molybdenum, selenium etc. make the geothermal water more precious. It is impossible to explain their importance in this small effort.

Chemical classification of geothermal mineral water based on their balneological effect is given in Table 4.

10. Commercial Establishment for Balneotherapic Practice

The geothermal waters are used for the commercial benefits in three different ways:

1. Development of geothermal spas with all the facilities that are available in a luxurious hotel.
2. Development of geothermal parlour or small pools with soaking tubs with or without snack bar and camping facilities.
3. The primitive undeveloped springs within the nature's lap without any services.

The first two are becoming popular in modern world; the third one still has significance to the trekkers and explorers.

11. Indian Hot Springs and Practice of Balneotherapy in India

India has a few numbers of hot springs and surprisingly, all are somehow related to Hindu mythology. The peculiarity of the nature of those springs draws attention since the historic past and associates them to mythological facts. The Rig Veda, a religious text of ancient India, described hydrotherapy treatments used for healing (Wardle 2013). Rudimentary health tourism in the form of pilgrimage has already been developed surrounding these hot springs. For example, at the temples of Manikaran and Badrinath in north India, thermal water forms the basis of the religious ritual carried out there, as well as the spiritual meaning attached to these places (Boekstein 2014). A balneotherapic practice in a primitive form has been practiced by the local 'pandits' of these areas. In Odisha, Taptapani thermal water is used for the treatment of skin, stomach and Rheumatic disorders.

It is apparent that the many hundreds of Indian hot springs might be utilised in balneotherapy and tourism, an aspect so far rather neglected except in Bihar, Himachal Pradesh and the West Coast area (Bowen 1989). A case study conducted by the Apollo Group of Hospitals showed that there are tremendous opportunities in India as far as medical tourism is concerned (Smith & Puczkó 2009). Detailed study and discussions are required to understand the possibilities of geotourism, health tourism and practice of balneotherapy surrounding the pilgrimage.

Geologically, nine potential areas are recognised in the subcontinent of India to develop geothermal and balneological services (Figure 6). These are:

1. The zone of subduction or Himalayan suture zone
2. North Indian Precambrian region or Sohana province
3. The zone in middle India associated with mid-continental rifts i.e. SONATA (SonNarmada-Tapi) Rift.

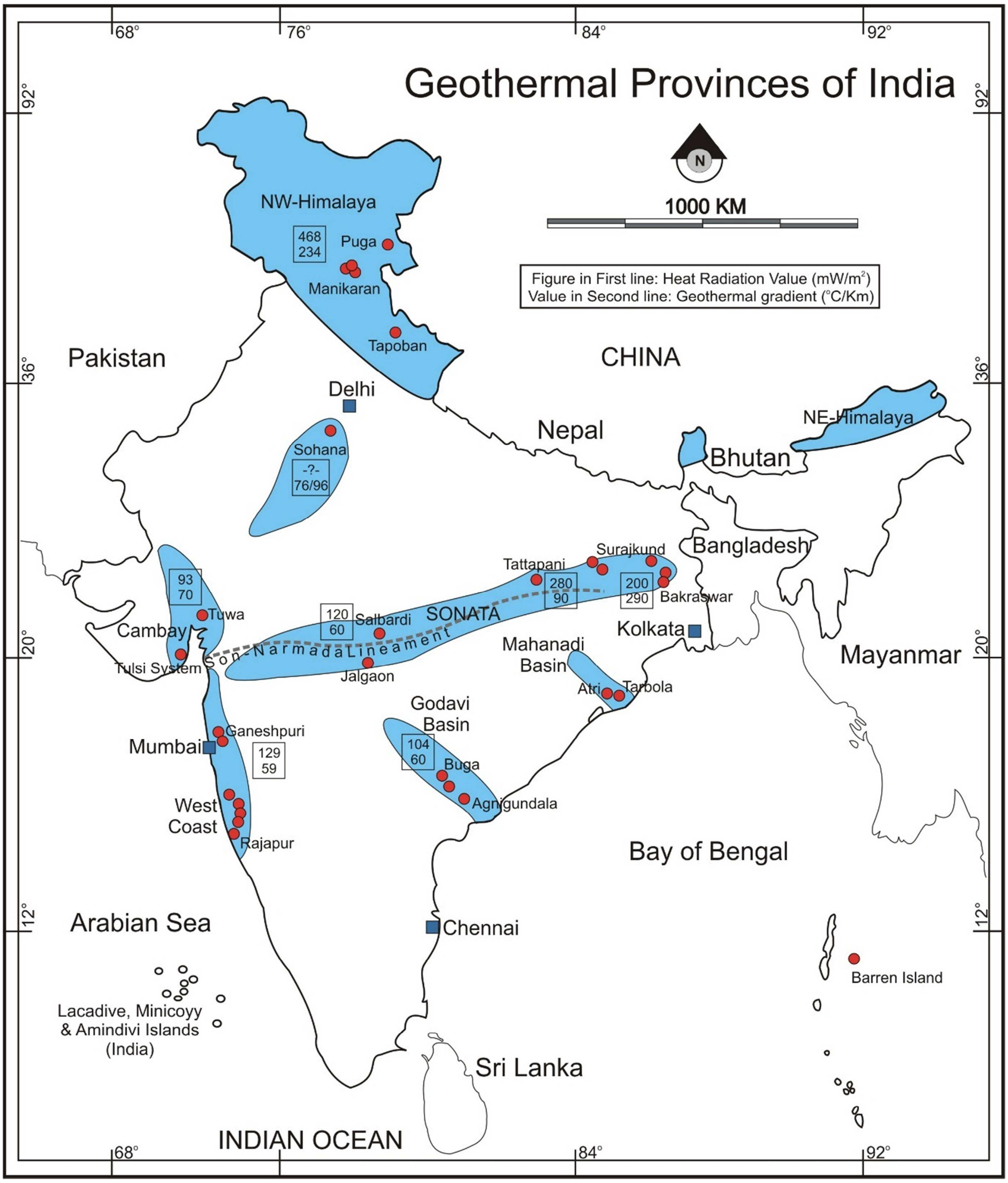


Figure 6: Major and representative Geothermal Provinces of India. (Modified after Chandrasekharam & Chandrasekhar 2010, 2015).

4. Sedimentary basin of Cambay and surrounding areas (Gujarat-Rajasthan Geothermal Province)
5. The thermal accumulation associated with Cretaceous-Tertiary volcanism below the Deccan Trap near west coast.
6. Mahanadi Basin
7. Godavari Basin

8. The Bay islands of Andaman & Nicobar and
9. North-east Himalayan subprovince.

Though Andaman and Nicobar islands is promising site for the development of spa and health resort, the close-door policy for the purchase of land in the area repels the investors. On the other hand, Kerala has developed health resort services based on Ayurveda, massage and traditional herbal medicine, but there is no notable thermal spring in the state.

A detailed state-wise list of hot spring sites is given in Table 5. The governments of Odisha, Himachal Pradesh and Maharashtra have taken the initiative to develop the hydrothermal sites. Bihar and Jharkhand are also interested in developing geotourism surrounding the hot-spring areas. In Birbhum district of West Bengal, Bakreshwar is famous for pilgrimage. However, most of the geothermal and hydrothermal sites in India are neglected. Except Puga and Chumathang in northern Himalaya, most of the geothermal reservoirs are low-temperature, mid to low-enthalpy type. Hence, it is not possible to harness electricity from those sites without the advancement of technology. The only possible ideas we can adopt is to convert them to geotourism sites with the facilities of health resorts, spas and balneotherapic centres. To draw the attention of foreign tourist and earn foreign revenue, the idea should be modern one, with the design of international standard.

Table 5: State-wise geothermal resources in India which have potential for balneotherapic use.

State	Name of the Geothermal Spot	Source of information
Andhra Pradesh	Mahandishwara Swamy temple at Mahanandi (Kurnool district [Dt.]), Bugga and Manuguru (Godavari valley)	Shanker et al. 1991, Chandrasekharam & Bundschuh 2002
Arunachal Pradesh	Dirang (West Kameng Dt.), Kitpi (Tawang Dt.), Bhalukpong (East Kameng Dt.), Thingbu and Tsachu (Tawang Dt.)	Shanker et al. 1991, Bora et al. 2006, Shanmugasundaram 2015
Assam	Gelepung (Dibrugarh Dt.) Garampani, Barpung (Karbi Anglong Dt.)	Shanker et al. 1991 and personal information
Bihar	Rajgir, Hot-springs of Munger dt. (Bharani, Bhimbandth Group; Hingania Group; Remeshwar-Lakshmiswar-Bhowarh Kund Groups; Rishikund Group; Sitakund-Phillips Kund Group; Sringrishi Group)	Shanker et al. 1991
Chattisgarh	Tattapani (Balrampur Dt.) and Surajkund (Faridabad Dt.)	Shanmugasundaram 2015, Roy 2008
Goa	No information available; assets remain untapped	Shanmugasundaram 2015
Gujarat	Tulsishyam (Junagarh Dt.),	Shanker et al. 1991, Mahala 2019

State	Name of the Geothermal Spot	Source of information
	Tuwa, Unani (Surat Dt.), (Cambay basin of Gujrat)	
Haryana	Sohana (near Gurgaon)	Shanker et al. 1991
Himachal Pradesh	Spread over Parbati, Beas, Satluj and Spiti valleys. Parvati Valley: Manikaran, Khirganga, Kasol, Awas. Satluj and Spiti valleys: Tapri, Chuza-Sumdo, Tattapani, Garam Kund and Vasisht (Bank of River Ravi)	Shanker et al. 1991, Chandrasekharam & Bundschuh 2002, Suryawanshi et al. 2019, Shanmugasundaram 2015, Chandrasekharam & Chandrasekhar 2008
Jharkhand	Tatta and Jarom in Palamau Dt. Surajkund, Lakshmi Kund, Brahma Kund, Ram Kund, Sitakund and Bagodar in Hazaribagh Dt. Tantloi, Dalahi and Bara Palasi (Dumka Dt.)	Shanker et al. 1991, Mukhopadhyay & Sarolkar 2012
Karnataka	Bendruteertha	Shanker et al. 1991
Kerala	Varkala	Shanker et al. 1991
Madhya Pradesh	Dhuni Pani, Salbardi	Shanker et al. 1991
Maharashtra	Rajapur-Unhale, Palghar, Anjaneri-Math, Rajwadi, Tural, Aravli, Khed, Unhavare-Farare, Vadvil, Pali, Akloli, Ganeshpuri, Satvili, Vajreshwari, Nimboli, Banganga, Nandni Gaygotha, Padusupada, Haloli, Sangh and Koknere	Shanker et al. 1991, Chandrasekhar et al. 2016, Suryawanshi et al. 2019
Manipur	Ukhrul	Personal information
Meghalaya	Jakrem	Shanker et al. 1991
Mizoram	No information available	
Nagaland	No information available	
Odisha	Atri, Taptapani, Deluajhari, Tarabalo	Shanker et al. 1991, Mahala 2019
Punjab	No Database on Hot-water Springs	Shanker et al. 1991
Rajasthan	Lalsot-Toda Bhim belt Jhunjhunu and Siwana area	Shanker et al. 1991, Moon & Dharam 1988, Singh et al. 2016
Sikkim	About 14 hot springs – all are of temp. >65°C; Phurchachu, Yumthang, Borang, Ralang, Taram Chu, Polat, Rishi and Yumesamdong (Yumey-Samdong)	Shanker et al. 1991, Kundu 2018, Shanmugasundaram 2015

State	Name of the Geothermal Spot	Source of information
Tamil Nadu	Mannargudi-Thiruthuraipundi area Costal tract of Arantangi	Shanker et al. 1991, Shanmugasundaram 2015
Telangana	Ushnagundam (Agnigundala) (near Bhadrachalam area)	
Tripura	No information available	
Uttar Pradesh	Most of the hotsprings are now located in Uttarakhand. No information available for Uttar Pradesh	Shanker et al. 1991
Uttarakhand	Sastradhara (Dehradun), Surya Kund (Near Rudra Prayag), Tapt Kund (on the bank of Alakananda), Gauri Kund (05 kms from Sonprayag) Bhagirathi Valley (Uttarkashi Dt.): 6 hot-water spring *viz.* Gangnani, Bhukki and Songarh; Darma Valley (Pithaurgarh Dt.): 1 hot-water spring; Madhya Maheswar Valley: 1 hot-water spring	Shanker et al. 1991, Suryawanshi et al. 2019
West Bengal	Bakreshwar, Dalahi and in Birbhum Dt.	Shanker et al. 1991, Ghose et al. 2002, Chandrasekharam & Bundschuh 2002
Jammu-Kashmir & Ladakh	Puga, Ladakh Dt., Chhumathang, Ladakh Dt., Panamik (Nubra Valley)	Shanker et al. 1991, Suryawanshi et al. 2019
Andaman and Nicobar Island	Barren Island & Batang	Shanker et al. 1991

12. Conclusion

Balneotherapy is a type of hydrotherapy. Balneology (lat. balneum: bath) is the science that deals with the healing effects of natural thermal waters, and their use in the treatment of diseases. Balneotherapy has a wide role in the management of various medical conditions. The geothermal waters of varied chemical composition can be used in balneotherapy treatment. The hot springs are distributed in different geological provinces all over India and provide low-enthalpy geothermal resources. Apart from space heating at many resorts, the introduction of balneotherapy makes the resort more attractive. Due to the multidisciplinary character of balneotherapy, there are ample opportunities to conduct research on the subject, especially in a country like India, and lots of innovative ideas may be developed and introduced in the field of geotourism and balneology.

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This volume, entitled "Changing Trends in Human Thought and Perspective: Science, Humanities and Culture, Part II", is an agglomeration of peer-reviewed articles authored by college teachers from various disciplines, who have explained in a lucid and easily understandable manner the gradual evolution of human knowledge and understanding in different areas of natural sciences, social sciences, humanities, and culture. Each article, reviewed by eminent academicians, presents a comprehensive description of the history of progressive development of a particular concept or idea during a period of time. This interdisciplinary discourse aims to enable the students from different branches of learning to enrich their own knowledge bases, and may also help the researchers and academicians to enhance their own works with the ideas from other disciplines.

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